Twenty-Year Mauritian Flying Fox (*Pteropus niger*) Management Plan for Mauritius Island.

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Adult Mauritian flying fox (*Pteropus niger*) Photo credit: Jacques De Speville

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Executive Summary

The Mauritian Flying Fox (*Pteropus niger*) is the only fruit bat endemic to the island of Mauritius off of Madagascar in the southwestern India Ocean. Known to most of the local fruit farmers on the island as a pest during the growing seasons, many individuals are poached or hunted for other purposes. Mauritian Flying Foxes can be found in colonies all around the island and travel long distances to foraging sites. This fruit bat faces competition and ecological pressures from invasive plant and animal species that now inhabit the island. With this conflict and an increasing negative interactions with humans, the government of Mauritius enacted mass culls to target the populations of flying fox. Because of this and other issues decreasing the overall population numbers, The International Union for Conservation of Nature (IUCN) Red List confirmed in 2018 that Mauritian Flying Foxes was an endangered species. The goal of this management plan is to increase the population to a sustainable level with focus on conservation efforts from the year 2020 to 2040. The objectives to achieve this goal include: (1) Conduct research on the biology, ecology, and behavior to determine proper population sizes and distribution of Mauritian flying foxes on the island of Mauritius in order to increase populations, (2) Increase the overall survivorship to 90% for all age classes, (3) Reduce mortality rates from poaching, and (4) Increase fruit farmer cooperation and educational programs for the locals and tourists. Proper management for the Mauritian Flying Fox is vital and with this plan put into action, the population on Mauritius can return to a stable number.

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Introduction

The Mauritian flying fox (*Pteropus niger*) was listed in 2018 as endangered by the International Union for Conservation of Nature Red List (Kingston et al. 2018). The classification of endangered was given to this species of fruit bat due to the dramatic decrease in population numbers by 50% in two years (Tollington et al. 2019). Major threats that caused the decrease of the species includes mass culls, poaching, introduction of invasive plant and animal species (Kingston et al. 2018), and overall lack of information about the biology, conservation efforts and education. This specific species of fruit bat is endemic only to the island of Mauritius (Florens and Baider 2019) located in the southwestern India Ocean near Madagascar. Colonies of Mauritian flying foxes are found all around the island but individuals are known to travel long distances from roost sites to forage (Oleksy et al. 2019).

Mauritian flying foxes are considered a keystone species in forest regeneration and seed dispersal (Oleksy 2015; Krivek 2017). Information such as this is not known by most who encounter Mauritian flying foxes like local and commercial fruit farmers. The farmers on the island see the bats as a pest since so much fruit is damaged due to the bats (Oleksy 2015). Mass culls have been implemented by the Mauritian government and as a result cut the population down to an inadequate size. Along with the culls, around 2,000 individual fruit bats are poached for consumption, medicinal uses and again being a pest. A battle between Mauritian flying foxes and invasive plant and animal also caused negative effects on the endangered fruit bat. Together, all these conflicts faced by the flying fox population on Mauritius have contributed to an overall decrease if numbers that could cause an extinction in 20 years' time if no management is taken.

Natural History

Species Identification

The Mauritian flying fox is a medium sized frugivorous bat ranging in body mass from 600-760 grams for females and 550-800g for males (Oleksy et al. 2019). The body of this fruit bat is cover in fur golden-light brown to brown in color and has a foxlike face that distinguishes it to the genus *Pteropus* (Amavassee 2015). Long and narrow wings can have a span from 135-160mm (Oleksy et al. 2019). The body mass and wing span of the Mauritian flying fox are adapted for long distance travel to foraging grounds during the night (Amavassee 2015). While the Mauritian flying fox is mainly nocturnal or crepuscular, much like most bat species, individuals have been documented foraging during the day (Nyhagen et al. 2005).

Distribution

Historically, Mauritian flying foxes once inhabited on both of the Mascarene Islands, La Réunion and Mauritius, in the southwestern India Ocean. The species was exterminated on La Réunion in the 18th century due to local hunting (Larsen et al. 2014). Records of small colonies have been documented back on La Réunion island recently (Oleksy et al. 2019). *Pteropus niger* was also once located throughout the archipelago but is now restricted to the island of Mauritius (Oleksy et al. 2019). Mauritian flying foxes are the last surviving fruit bat endemic to Mauritius (Florens and Baider 2019).

Figure 1 Distribution of Mauritian flying fox (Pteropus niger) on the Mascarene Islands of La Réunion and Mauritius. Map modified from Anthony et al. 2018.

Habitat

The Mauritian flying fox is a terrestrial species that inhabits forested areas around the island of Mauritius. Bats tend to travel into fruit farms on the island which causes friction with the local people. Roosting sites have been documented in many different type of areas all over the island. Some large bats have been known to roost in tree in open areas for the sun exposure (Oleksy et al. 2019). Individual bats tend to move between multiple different roosts within a certain range (Larsen et al. 2014). Roosts are found near or at the top of ridges with slopes of 30-45° in primary forests (Nyhagen et al. 2005). Other forested areas that are mixed of native and introduced trees can be used as roosting for the Mauritian flying fox (Nyhagen et al. 2005). Locations of roost fluctuate during the year on the island. Colonial roosts are formed in the southern part of the island during the winter and the northern part during the summer (Oleksy et al. 2019). Foraging habitat selection is mainly influenced by the availability and quality of the area which in turn determines the overall range across the island of Mauritius (Amavassee 2015).

Diet and Food ecology

Mauritian flying foxes are a species of fruit bat and are classified as frugivores. Their diet is composed of fruit, flower parts, nectar and leaves (Nyhagen 2004). Depending on the time of year, the amount of each food type ingested did fluctuate (Banack 1998). Mauritian flying foxes do have species of trees they feed on more frequently. The fruit of the *Labourdonniasia glauca* (Sapotaceae) and *Protium obtusifolium* (Burseraceae) trees are popular among this species of fruit bat. The fruit produced by these trees fall under a classification according to a set of traits following the concept of bat-fruit syndrome (Nyhagen 2004). The *L. glauca* tree peaks fruit production in August and September (Krivek 2017). Fruit bats, including *P. niger*, prefer ripe fruit over unripe fruits being that the ripe fruit produces more juice, softer pulp, and lower levels of secondary plant metabolites (Amavassee 2015).

During the ripe fruit season, typically very short time between the months of November to February (Krivek 2017), Mauritian flying foxes do face pressures from other fruit competitors. The *L. glauca* tree fruit is popular with the invasive species of long-tailed macaques (Krivek 2017). The macaque attacks the fruit of the *L. glauca* tree more frequently, creating pressure on Mauritian flying foxes and decreasing overall fruit numbers (Krivek 2017). Fruit farms are very common all over the island of Mauritius and farmers run into problems with the flying fox quite often. Litchi orchards see a large increase in damaged fruit during the peak ripening season do to bats (Oleksy 2015). With these pressures, Mauritian flying foxes do move between different forested areas across the island to find suitable food resources and availability (Oleksy et al. 2019).

Reproductive Characteristics

Fruit bats live in colonies and have been documented mating in pairs (O'Brien 2011). The mating season occurs during April and May followed by a young being birthed in October (O'Brien 2011). It is common in many fruit bat species, including *P. niger*, that adult female bats only produce a single offspring each year (Oleksy et al. 2019). Being unable to forage before learning to fly, juvenile flying foxes depend on the mother to nurse and gain the nutrients it needs (O'Brien 2011). This period of nursing tends to be 4-6 months and the young may be dependent up to a year in this species fruit bats compared to other terrestrial mammals (Pierson and Rainey 1992). Juveniles do grow quickly during that time and join the social roosting group once they become dependent (O'Brien 2011).

Since the data is lacking regarding Mauritian flying foxes' survivorship at each life stage and fecundity estimates, the African Straw-colored fruit bats (*Eidolon helvum*) and the Spectacled fruit bats (*Pteropus conspicillatus*) were used as surrogate species. Each surrogate is found in geographically similar habitats and Spectacled fruit bats are within the same genus (Fox

2006, Hayman et al. 2012). Neonates are offspring less than 2 months old, juveniles are considered 2 to 6 months old, sexually immature individuals are 6 to 24 months old and adults are older than 24 months or 2 years (Figure 2; Peel at al. 2016). The life-span of bats in the genius *Pteropus* are known to live between 14-16 years (Peel et al. 2017). With data taken into consideration along with the sensitivity matrix (Appendix D), the adult stage class is curial for overall survival. For the focus of this management plan, actions will be directed towards increase the survivorship in all age classes to enhance the increase in the overall population.

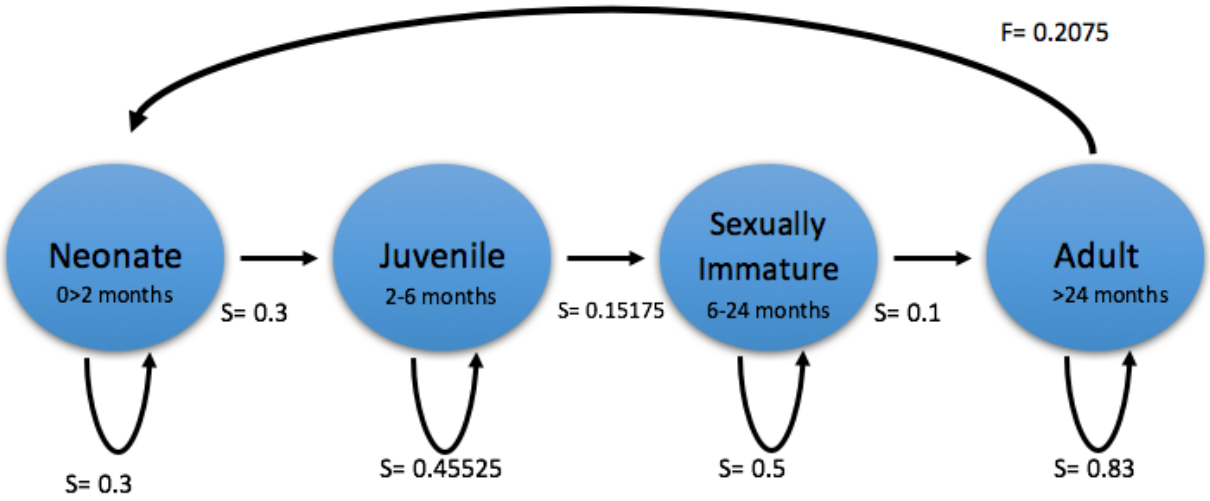

Figure 2. Life cycle diagram for the Mauritian Flying Fox (*Pteropus niger*) based on the African Straw-colored Fruit bat (*Eidolon helvum*) and Spectacled Fruit bat (*Pteropus conspicillatus*) as surrogate species (Fox 2006, Hayman et al. 2012, Peel et al. 2016, Peel et al. 2017 and Pierson and Rainey 1992).

Conservation Needs

Ecological

Mauritian flying foxes (*Pteropus niger*) have a vital role in seed dispersal, pollination and forest regeneration for the native flora on the island of Mauritius (Oleksy 2015; Krivek 2017). Therefore, a primary threat to *P. niger* putting pressure on distribution is habitat loss and fragmentation. The island of Mauritius has seen an influx of development including human settlement and agriculture (Florens 2013). Native forested areas have been broken up and fragmented creating extreme challenges for conservation purposes. The quality of those native forests have declined with about 2% consisting of relatively good area left (Amavassee 2015). With the fragmentation and decrease quality of the native forest, roosting and foraging habitats for the *P. niger* are greatly being effected.

Invasive plant and animal species have been introduced causing competition and pressure on the *P. niger* diet (Krivek 2017). The native forests are under stress from invasive alien plant species like Strawberry guava (*Psidium cattleianum*) (Monty et al. 2013), privet (*Ligustrum robustum*), rose apple (*Syzygium jambos*) and cinnamon (*Cinnamomum verum*) (Krivek 2017). Contributing to the pressure are the invasive mammals that include the Javan deer (*Rusa timorensis*), the wild pig (*Sus scrofa*) and the long-tailed macaque (*Macaca fascicularis*) have all been introduced to Mauritius (Krivek 2017). With the new invasive plant and animal species dominating forests, the native vegetation is being compressed and depleted causing a decrease in seed availability for the *P. niger* (Krivek 2017). For example, the long-tailed macaque preys on the fruit *Labourdonniasia glauca* tree, of which *P. niger* frequently feeds as well (Krivek 2017). Fruit of roughly the same size and ripeness are desired by both *P. niger* and *M. fascicularis* causing competition during peak growing seasons (Krivek 2017). Alien plants are threatening native growth of vital food sources and canopy cover valuable to *P. niger* by overcrowding with

weedy growth (Krivek 2017). Overcrowding greatly reduces fruit and flower reproduction (Krivek 2017) that the *P. niger* is significantly affected by. Management of invasive plant and animal species on Mauritius is critical to increase the chances for *P. niger* populations.

Economic and Sociocultural

The human-bat conflict is certainly a crucial threat to Mauritian flying fox populations. Hunting of *P. niger* was primarily done for consumption by locals, as well as the possible medicinal properties and for the sport (Vincenot et al. 2017). Populations of *P. niger* were at the high of 92,000 in 2013 documented by the government (Florens and Baider 2019). The fruit bats were causing such damage to local and commercial fruit farms on the island. Fruit farmers started to view the species as a pest, as the bats were consuming 50,000kg of litchi fruit per year with increasing overall damage by 10% every year (Oleksy 2015). The government moved to remove *P. niger* from the protected species list (Oleksy 2015) and the first mass-cull took place in November/December 2015 along with a second cull during the breeding season of 2016 (Florens and Baider 2019). Illegal poaching of the flying fox has and continues to rise removing approximately 2,000 bats a year (Florens and Baider 2019). These killings started to affect the ecosystem and biodiversity (Florens and Baider 2019) leading to the *P. niger* being listed as endangered on the IUCN Red list (Kingston et al. 2018).

Legal

The Mauritian flying foxes have been legally protected by the government since 1993 (Florens 2013). The mass-culling actions were legally put in place but the illegal taking of the fruit bats by poacher or fruit farmers have not been punished properly. Government penalties and fines have not been strongly implemented for the illegal hunting that still occurs on the *P. niger* populations. As stated previously, *P. niger* is listed as endangered on the IUCN Red list since November 2017 (Kingston et al. 2018).

Statement of need

Mauritian flying foxes are endangered and in need of a recovery plan for the island of Mauritius. Essential native forest ecosystems are seeing huge threats from fragmentation and decreased quality from invasion of alien plant and animal species. A solution to fruit farms being overharvested or damaged by the flying fox needs to be resolved in a way that does not degrade food quantity and decrease the illegal killings. With all the evidence backing up that the Mauritian flying fox is a keystone species (Anthony et al 2018) and the need for protection, implementation of this management plan will increase the chance of this species coming off the endangered list.

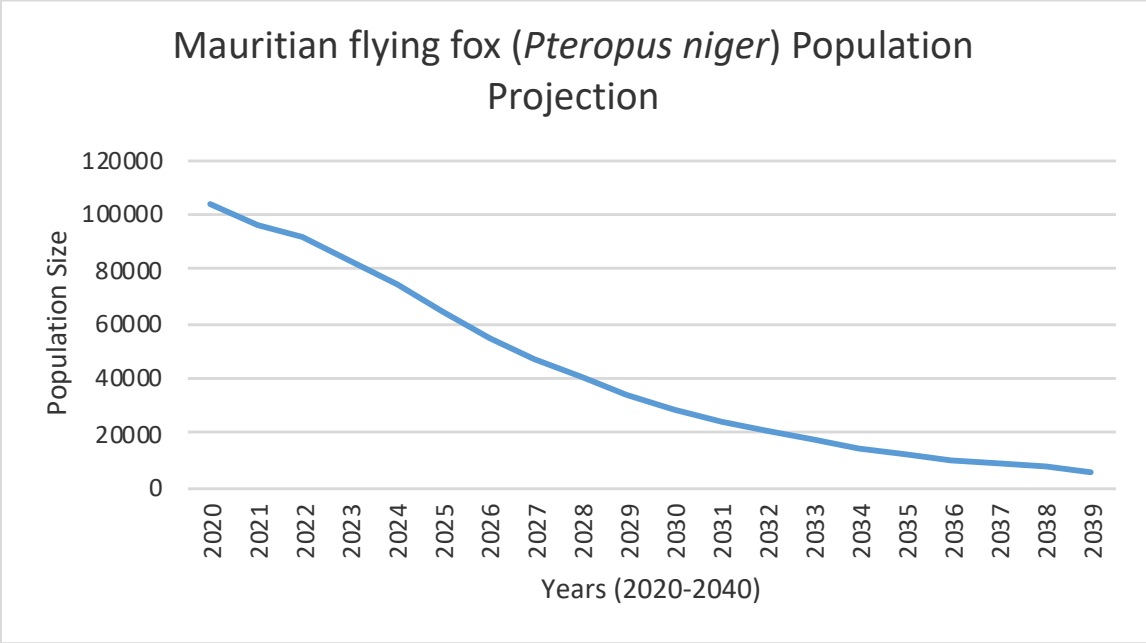

Figure 3. The current Mauritian Flying Fox (*Pteropus niger*) population projection from 2020 to 2040 on Mauritius Island. This projection was formulated from survivorship and fecundity based on the African Straw-Colored Fruit Bat (*Eidolon helvum*) and Spectacled Fruit Bat (*Pteropus conspicillatus*) from collected data from Peel et al. (2016), Peel et al. (2017), Hayman et al. (2012), and Fox (2006).

Management

Goals and Objectives

Goal: Increase the population of Mauritian flying foxes to a sustainable level on the island of Mauritius and effectively maintain a stable population from 2020-2040 while focusing on conservation efforts for the species and the ecosystem.

Objective 1- Conduct research on the ecology and behavior to determine proper population sizes and distribution of Mauritian flying fox on the island of Mauritius in order to increase populations.

Objective 2- Increase the overall survivorship to 90% for all age classes.

Objective 3- Reduce mortality rates from poaching.

Objective 4- Increase fruit farmer cooperation and educational programs for the locals and tourists.

Actions

Objective 1- Conduct research on the ecology and behavior to determine proper population sizes and distribution of Mauritian flying fox on the island of Mauritius in order to increase populations.

Action 1.1- Capturing individuals and tagging the fruit bats with GPS devices to track movement and areas of high inhabitances can be documented. The data from the trackers will help create a basis for increasing the knowledge on *P. niger* ecology and behavior. With a focus on movement ecology, Oleksy et al. (2019) used leather collars with trackers implanted within to track movement of the fruit bats around the island of Mauritius. The tags did not affect the behavior and had successful results in located over 50 roost sites (Oleksy et al. 2019). The GPS tracking ability can be utilized as a way to find more individuals, new colonies and gather a better understanding of current population numbers while focusing mainly on distribution.

Action 1.2- GPS tracking data from action 1.1 and additional movement ecology that has already been documented (Oleksy et al. 2019) can help determine areas of focus for conducting habitat suitability index (HSI). With conducting HSI in determined areas, data will be gathered concerning preferred forest types for roosting, breeding, and foraging. These analyses should happen in the first year of the management plan to increase the quality of important habitat areas for the fruit bats.

Action 1.3- Analyzed findings from the HSI in action 1.2 and pictures captured in action 1.1 will aid researchers to prime roost location around the island of Mauritius. Once located, documentation of these regions must be made. These areas will then need to be protected and maintain to the conditions required for the survival of *P. niger* populations. Protection of said roost sites is going to be vital to increase of social interactions and safety for individuals from predators and inclement weather (Oleksy et al. 2019).

No action- If there is no action taken and no further scientific data has been gathered *P. niger* populations, there will continue to be a decrease and possible extreme endangerment of this species (See Fig. 3). Observation and data must be collected to properly comprehend the management necessary to protect this fruit bat species.

Final course of action- Actions 1.1, 1.2, and 1.3

Assessment protocol- Objective 1 will be successfully accomplished by data collected from the GPS tracking devices completed first, followed by conducting habitat suitability index analyses and finally protecting vital roost site for future generations. The data will be analyzed, finalized and published for scientist and the general public by the end of year five of the management plan to better understand Mauritian flying fox biology, ecology, and behavior.

Knowledge of breeding habits must be a main focus to better understand the overall reproductive lifecycle of *P.* niger. This can also increase the awareness about what actions are needed to conserve this species of fruit bat.

If this objective is not successful, it should be questioned why the research was not conducted. Problems with improper field data from GPS trackers not functioning correctly could arise and have to be reevaluated to gain proper data. Possible funds for the research could have been lost or insufficient. If this is case, federal funding needs to be obtained for the future research of Mauritian flying fox.

Objective 2- Increase the overall survivorship to 90% for all age classes.

Action 2.1- Create and provide new food plots for *P. niger* to forage and inhabit. With new areas for foraging, pressure will be taken off of local and commercial farms where the fruit bats cause damage to harvestable fruit during the growing season (Oleksy 2015). New plots should be planted with *Labourdonniasia glauca* trees, mango trees (Nyhagen 2004), and lychee trees (Tollington et al. 2019) for *P. niger* to feed. Since this species of fruit bat is seen as a pest by farmers (Oleksy 2015), new fruit plots will be a step towards keeping bats out of possible poaching areas.

Action 2.2- Along with new food plots in action 2.1, food corridors connecting roost sites and the new foraging plots will create a more effective overall habitat for *P. niger* populations. Highly populated food plots will be monitored and those areas will be selected for creating connecting corridors. With connections between roost sites and food corridors, this will decrease energy expended flying long distances to foraging sites (Oleksy et al. 2019).

Action 2.3- Invasive species of plants and animals need to be managed to decrease competition and pressure put of the *P. niger* population. The long-tailed macaque is the main source of foraging competition against *P. niger*. The macaque is an invasive that has an overall negative effect on the impact of the native flora and fauna (Krivek 2017). Relocation by trapping all macaques within a highly occupied *P. niger* habitat should be the first step in managing the invasive population. If relocation does not seem effective in decreasing competition, a more permeant removal system must be put into action.

A solution that has been tested on Mauritius to be successful to regeneration on native plants is weeding areas that have been dominated by invasive alien plants. Monty et al. (2013) weeded out invasive alien plants from attacked forested areas and documented healthier seed density and regeneration after weeding. Bat foraging is also high in weeded areas based on the amount of ejecta left behind from the bats over non-weeded, invasive filled areas (Krivek 2017). With this positive correlation of increased foraging of *P. niger* in weeded areas, this method of controlling the invasive alien plants should be implemented within forested areas inhabited by the fruit bat.

No action- If this action is not followed, it is likely that the endangered *P. niger* population will continue to struggle with competition from many different variables and not successfully repopulate.

Final course of action- Actions 2.1, 2.2, and 2.3.

Assessment protocol- This objective will be achieved when the overall survivorship of *P. niger* adults (>24months old) is up to 90%. With creation of new food plots connected by new corridors with suitable habitat and food sources incorporated, this will increase many important

social interactions within *P. niger* colonies (Oleksy et al. 2019). The solutions provided in action 2.3 for dealing with invasive plant and animals will decrease the competition and difficulties *P. niger* populations face when foraging. When all actions should be fully implemented by year ten of the management plan to ensure successful outcomes and possible adjustments if needed.

If little to no success comes within the time frame from the actions planned, reassessment of each must be taken. If the food plots are not being utilized among *P. niger* populations, relocated individuals into the areas could be a potential alternative. Invasive plants must be regulated and continually weeded out of areas. If relocation of invasive macaques is not effective, permanent removal may be considered.

Objective 3- Reduce mortality rates from poaching.

Action 3.1- Conservation law enforcement must be stricter when it comes to protecting this species of endangered fruit bat. Around 2,000 individuals are poached per year by the locals on Mauritius (Florens and Baider 2019). Known poaching areas must be monitored by conservation law enforcement officers during the breeding season and peak fruit seasons. Poaching numbers have increased since the culls were implanted and government authorities have not taken steps to correct it (Florens and Baider 2019). Fines must be given to convicted poachers. By increasing enforcement, population numbers of *P. niger* may be able to return to normal.

Action 3.2- A survey will be distributed out to fruit farmers around the island to gauge a better understanding of how *P. niger* populations affect the farms (see Appendix A). This survey will gain information on how much damage is caused, how much is lost dollar wise, if the farmers already take precautions to protect their fruit legally, and willingness to work with bat experts to

learn about the importance. The data will be collected and further steps will be determined afterwards.

Action 3.3- Encourage fruit farmers to install bat deterring systems during peak growing season to protect the harvest. Trimming down tall trees that are highly foraged by the fruit bats within the farms and keeping branching low could deter individuals (Oleksy 2015). Nylon netted bags have been put around the fruit during the growing season and it effectively deterred the fruit bats from foraging on the sellable corps (Tollington et al. 2019). This method of management would only be necessary during the peak growing season when the fruit needs to be harvested for market (Tollington et al. 2019). Bat deterrent systems can also be installed during the fruit growing season to keep individuals from foraging. Deterring the fruit bats will decrease conflict between humans and possibly have a positive outcome. If deterring systems are unsuccessful, relocation of individual bats could be an alternative.

No action- If no action is taken, poaching of *P. niger* will continue and possibly increase to harm the already declining population pushing it to extinction.

Final course of action- Actions 3.1, 3.2, and 3.3.

Assessment protocol- Decreasing mortality numbers in the first years of management will be vital for the population of Mauritian flying fox. Focus needs to be put on communication with the local and commercial fruit farmers. Alternatives about handling Mauritian flying foxes during peak fruit production season must be addressed with a humane approach. Monitoring of new techniques of protecting fruits with nylon netting, bat deterring systems and possible relocation of individuals will continue throughout the length of the management plan. A survey will be created for before and after the new laws and monitoring techniques are put into action.

Strict legal actions must be taken if illegal poaching is still present and an increase of overall law enforcement must be implemented.

If these actions in objective 3 are not controlled, the numbers of Mauritian flying fox will continue to decrease do to illegal hunting. If the government does not enforce the punishment for poaching, then people will continue to take it into their own hands. If new techniques to remove the fruit bats or protect the fruit tree is not working, reevaluation of the methods must occur to produce better outcomes. Communication with the fruit farmers must happen frequently throughout growing seasons and not subside.

Objective 4- Create awareness for tourist and locals of Mauritius to promote conservation practices and educate importance of Mauritian flying fox.

Action 4.1- Informational flyers (see Appendix B) will be distributed around Mauritius in areas highly populated with tourists and locals. The flyers will include information about how the population of *P. niger* are a keystone species (Anthony et al 2018), why they are endangered, and what the general public can do to save the species. With this information, flyers can be put up in lobbies of hotel, informational stations, airport, local school and any place where the word can be spread to all people around the island.

Action 4.2- Educational programs should be provided in local schools and visitor centers to increase the amount of information available of the endangered fruit bats. In Mauritius, *P. niger* is a keystone species that has a large role in seed dispersal and forest regeneration (Oleksy 2015; Krivek 2017). This information needs to be known and emphasized among the people on the island to spread awareness.

Action 4.3- A sighting form (see Appendix C) to document Mauritian Flying Fox sightings will be available for public assess around the island year round. By completing and sending in the forms of *P. niger* sightings, information can be collected and that data can be used to identify new or previously known populations. Management areas can use this to increase their knowledge and adopt to any changes if needed.

No action- If no action is completed, no information about the importance of this fruit bat species will continue to be unknown and no additional help will be provided.

Final course of actions- Actions 4.1, 4.2, and 4.3.

Assessment protocol- With educational programs, informational flyers, and sighting forms all available for locals and tourist, this objective will be successful. Getting this information out early on in the management plan will be fundamental for encouraging the community of Mauritius to get involved. Flyers with information about the endemic fruit bat of Mauritius will be made and put at highly populated tourist areas. Sighting forms will be sent out with hopes that the locals will participate and increase the current data on *P. niger* findings. This can help with locating new colonies or reassuring that a colony is still present in a certain area. Education programs all around the schools on the island can be implemented to help increase awareness.

If this objective is not achieved, reevaluation of the educational programs must be modified along with flyers and sighting forms increased and moved into new locations. If flyers are lost or destroyed, new ones will be distributed to keep developing the publics knowledge on the Mauritian flying fox.

Conclusion

This management plan for the endangered Mauritian flying fox on the island of Mauritius could potentially help increase overall population numbers in the next twenty years. The success of this plan will revolve around gaining more knowledge about this fruit bat species, conserving and creating new vital habitat, and cooperation from all of the general public. Ecological pressure from invasive plant and animal species, mass culls along with poaching, conflict with fruit farmers and an overall lack of information about Mauritian flying foxes are all reasons for the decreased numbers in population. Focus on the survival of neonate individuals reaching adulthood and successfully reproducing would greatly effect population numbers. Implementing all actions with the goal of increase the population with focuses on research, conservation and education will allow the species to thrive again in the native habitats. New thriving numbers of Mauritian flying foxes can help increase forest regeneration and seed dispersal, allowing native flora to thrive again as well. Gathering public feedback and increase in educational presence around the island will create a more positive picture for the endemic fruit bats. Furthermore, if this plan stays on track with the time line and overall goal, Mauritius will see success for the Mauritian flying foxes' population.

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Appendix A

Mauritian Flying Fox (*Pteropus niger*) impact on fruit farms

This survey is meant to gauge a better understanding of how farmers of the island of Mauritius view fruit bats and how they deal with the pests. With this information, steps towards properly managing against fruit bats in a legal, safe manner.

1. Are you a fruit farmer in Mauritius?
   a. Yes, if so what fruits do you farm? _____
   b. No

2. What is your level of knowledge about the Mauritian Flying Fox? (ex. Habitat, biology, significance to the ecosystem, etc.)
   a. Very Knowledgeable
   b. Knowledgeable
   c. Somewhat knowledgeable
   d. I don't know much about the species of fruit bat
   e. Other- _____

3. What time of year are the fruit bats active in the farms?
   a. Year round
   b. Peak growing season
   c. Summer months
   d. Spring months
   e. Other- _____

4. Do you have fruit protective or bat deterring methods in place around your farm? (check all that apply)
   • Bags around fruit (ex. Nylon netted bags) • Trimming of trees
   • Bat deterring sonar system • None of these • Other(s):_____

5. Would you be willing to working with bat experts and installing new methods of bat deterring systems and/or protective measures for fruit?
   a. Yes
   b. No
   c. Maybe
6. Please provide an address for your farm-
   _____

Thank you for completing and returning this survey. This information will be analyzed and taken into account during the future steps in this management plan.

Appendix B

DID YOU KNOW?

The Mauritian Flying Fox (*Pteropus niger*) is a keystone species only endemic to the island of Mauritius. This fruit bat is extremely important in forest regeneration.

DID YOU ALSO KNOW?

The ICUN listed this species of fruit bat as endangered in 2018 due to mass culls, poaching, and pressure from invasive plants and animals on the island.

But with your help, this fruit bat can thrive again!

Without proper management in the near future, Mauritian Flying Fox populations will continue to decline. To help the fight against extinction for this species, ask question to local conservation areas and get educated. Every little bit of knowledge can help!

MAURITIAN WILDLIFE FOUNDATION

Flyer created by K. McGinnis March 30, 2020

Appendix C

Mauritian Flying Fox (*Pteropus niger)* sighting form

This form is to be filled out by any individual any time a Mauritian Flying Fox is seen. Please fill out as much information below as possible. Answers help identify population numbers around the island of Mauritius, which is vital to management.

1. Date of sighting _____

2. Time of day
   a. Morning
   b. Afternoon
   c. Evening
   d. Other _____

3. Location _____

4. Where did you see the fruit bat?
   a. In a fruit farm
   b. In the deep forest
   c. Flying in an open area
   d. Other _____

5. Did you see multiple bats?
   a. Yes, if so how many? _____
   b. No

6. Any other information you can provide, please list below.

Thank you for completing and sending in this sighting form. You have been a great help in the goal to manage Mauritian Flying Fox populations on the island.

Appendix D

Life stage structured matrix for *Pteropus niger* population projection.

	***F*(n)**	***F*(j)**	***F*(si)**	***F*(*si2*)**	***F*(*a*)**
Neonate:	0.425	0	0	0	0.45
Juveniles:	0.425	0.675	0	0	0
Sexually immature:	0	0.225	0.75	0	0
Sexually immature(2):	0	0	0.15	0	0
Adults:	0	0	0	1	0.9

Sensitivity matrix (below) showing that adult survivorship has the largest effect on the population of *Pteropus niger*.

	Sensitivity matrix				
	F(n)	***F*(*sj*)**	***F*(*lj*)**	***F*(*sa*)**	***F*(*a*)**
Neonate	0.2274	0.0190	0.0084	0.0010	0.0650
juveniles	0.0450	0.0346	0.0152	0.0018	0.1181
Sexually immature	0.1155	0.0889	0.0391	0.0046	0.3035
Sexually immature(2)	0.3988	0.3068	0.1349	0.0160	1.0479
Adults	0.3371	0.2593	0.1140	0.0135	0.8857